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NTIA REPORT 92-286

92-9

FEASIBILITY OF RELOCATING NON-GOVERNMENT FIXED SYSTEMS INTO THE 1710-1850 MHz BAND



report series

U.S. DEPARTMENT OF COMMERCE • National Telecommunications and Information Administration

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92-91

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ABSTRACT

The United States is identifying spectrum in the 2 GHz range for new, emerging technologies. Federal Government spectrum has been suggested as an option for accommodating FCC licensees relocated to other bands to make room for these new technologies. This report documents a study that examines the feasibility of relocating non-government fixed service systems into the 1710-1850 MHz band. It summarizes current use of 1710-1850 MHz and the bands allocated for non-government fixed service use in the 1850-2200 MHz range. The study found that 1710-1850 MHz could accommodate a limited number of 2 GHz private-sector stations. Guidelines, based on path length, are developed that could be used to determine which 2 GHz private-sector fixed systems are potential candidates for accommodation in the 1710-1850 MHz band.

KEY WORDS

Emerging Technologies
1710-1850 MHz Band
1850-2200 MHz Band
Fixed Service

EXECUTIVE SUMMARY

The United States is in the process of identifying spectrum for emerging telecommunications technologies. These new services hold the promise of significant job creation, enhancements in industrial productivity, and improved public services. The spectrum allocation focus for these services within the United States, and throughout much of the world, is on the frequency bands around 2 GHz. Recognizing the increasing spectrum needs of these emerging technologies, the Federal Communications Commission (FCC) issued a Notice of Proposed Rule Making (NPRM) on making spectrum available to encourage innovation in the use of new telecommunications technologies. The initial target frequencies for these new technologies are the bands allocated for non-government fixed use in the range 1850-2200 MHz (the "2 GHz band").

The FCC in its NPRM, and a number of parties in their comments in response to the Notice, raised the issue of whether Federal Government spectrum should be considered as an option for accommodating new technologies or those private-sector licensees that would be relocated from the 2 GHz band to make room for the new technologies. This report documents an analysis of the potential capacity available in the Federal Government 1710-1850 MHz band. The 1710-1850 MHz band is intensively used by the Federal Government for a number of services, including fixed microwave, high power satellite control stations, air and land combat training systems, civil disaster response, and radio astronomy. These systems provide critical public services and represent an investment in excess of \$10 billion of taxpayer funds. It became clear early in the analysis that, because of the extent and variety of Federal use in the 1710-1850 MHz band, moving new technologies into this band in any substantial way would not be possible. The analysis, therefore, focuses on the more germane issue of whether some accommodation of incumbent 2 GHz private-sector fixed microwave links into this band is feasible.

The analysis shows that, due to the present use of the 1710-1850 MHz band and the need to maintain flexible continued use by Federal agencies, this band could not accommodate all or even most of the existing 2 GHz private-sector fixed microwave links. In particular, accommodation of 2 GHz links in areas where there are major military electronic and missile test ranges, major Government training areas, and along the United States-Canadian border would be especially difficult.

However, the analysis also concludes that sufficient spectrum is available in most parts of the country to support a limited number of 2 GHz private-sector fixed microwave links in the 1710-1850 MHz band. This report presents possible guidelines, based on path length and climate/terrain conditions, that could be used to determine which 2 GHz private-sector fixed microwave links are potential candidates for accommodation in the 1710-1850 MHz band. It is estimated that up to 2% of the total current non-government fixed microwave links may need to remain in the 2 GHz bands. It will be necessary to conduct a more detailed examination on a case-by-case basis to determine whether accommodation in the 1710-1850 MHz band is possible for those specific links that can, in fact, neither operate reliably if relocated in higher frequency bands, nor continue to operate in the 2 GHz band without causing interference to new systems licensed by the Commission. NTIA will need to coordinate with the Commission to establish the technical rules and coordination procedures necessary to identify the links that satisfy these criteria, evaluate the feasibility of relocation in the 1710-1850 MHz band, and if feasible, implement such relocation.

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SECTION 1 INTRODUCTION

BACKGROUND

The National Telecommunications and Information Administration (NTIA) is responsible for managing the Federal Government's use of the radio frequency spectrum. Part of NTIA's responsibility is to "... establish policies concerning spectrum assignment, allocation and use, and providing various departments and agencies with guidance to ensure that their conduct of telecommunications activities is consistent with these policies".¹ In discharging these responsibilities, NTIA assesses spectrum utilization, identifies existing and/or potential compatibility problems among the telecommunications systems that belong to various departments and agencies, provides recommendations for resolving any compatibility conflicts that may exist in the use of the radio frequency spectrum, and recommends changes to promote spectrum efficiency and improve spectrum management procedures.

The United States is facing a shortage of radio frequency spectrum for the development of new mobile communications technologies. The introduction of technical advances has increased the need for spectrum to foster the growth and development of new services and to provide for expansion of existing services to handle these newer technologies.² Recent advances in signal processing and digital techniques have made possible a broad new range of radiocommunication services for commercial, public and personal applications. Emerging technologies include personal communications systems, wireless computer networks, digital audio radio and mobile satellite services. These new services hold the promise of significant job creation, improvements in industrial productivity, and improved public services and personal conveniences.

The focus for these services within the United States and throughout the world is in the frequency bands between 1 and 3 GHz. This frequency range offers numerous technical advantages for mobile wireless communications, including small lightweight equipment, favorable radio propagation characteristics and less intense use by existing radio services. The frequency bands below 1 GHz have been very intensely used by services such as radio and television broadcasting, cellular radio, conventional land, airborne and shipboard mobile communications. The intensity of use is illustrated by the fact that 85% to 90% of the licensed transmitters in the United States are operated below 1 GHz. Introducing a whole new class of radiocommunication services in this extensively used portion of the spectrum is clearly impractical. While frequencies above 3 GHz are used less intensely, technical factors tend to limit their application for mobile use.

¹ Manual of Regulations and Procedures for Federal Radio Frequency Management, National Telecommunications and Information Administration, Washington, D.C., Revised September 1991, page 1-2, Part 6.08.

² Notice of Inquiry; Request for Comments, *Current and Future Requirements for the Use of Radio Frequencies in the United States*, National Telecommunications and Information Administration, 57 Fed. Reg. 25,010 (June 12, 1992).

At the recently completed 1992 World Administrative Radio Conference (1992 WARC) in Spain, particular focus was on the 1 to 3 GHz frequency range, with the specific result that all bands between 1710 and 2290 MHz were made available for mobile communications on a worldwide basis. The specific frequency bands 1885-2025 and 2110-2200 MHz are intended for use, on a worldwide basis, by administrations wishing to implement the future public land mobile telecommunication systems (FPLMTS). Appendix A shows the international allocation table for the 1710-2290 MHz band that resulted from the 1992 WARC.³ To accommodate the varying interests of the international community, the frequency allocations for this range were modified at the WARC from one contiguous block of spectrum to eleven individual blocks of spectrum.

Recognizing the increasing spectrum needs of these emerging mobile technologies, the Federal Communications Commission (FCC) released a Notice of Proposed Rulemaking (NPRM) in February 1992 on redevelopment of spectrum to encourage innovation in the use of new telecommunications technologies.⁴ In this NPRM, the FCC addressed the need for emerging technologies, frequency bands, cost and feasibility of relocating incumbent systems, amount of realizable spectrum, proposed reallocations, international compatibility and transition plans. The FCC concluded that if innovative technologies are to flourish then some existing services would have to be reaccommodated. To facilitate this reaccommodation, the FCC proposed a market-based "negotiated reallocation" plan, under which the incumbent fixed microwave users could negotiate with new users for access to 2 GHz spectrum in exchange for financial remuneration.

Parties responding to the NPRM differ as to whether new service providers should be allocated spectrum in the 2 GHz bands, with many incumbent users opposing such allocation, and potential new service providers supporting it. One view shared among many parties responding to the NPRM was that the spectrum under consideration should be broadened to other bands, including bands allocated for exclusive Federal Government use.

NTIA recently released a report⁵ describing Federal spectrum usage in the 2 GHz region, specifically the 1710-1850 and 2200-2290 MHz bands. The extracts from the findings from that report are provided for convenience in Appendix B of this report. The findings describe the varied usage of these bands by Federal agencies, including fixed and mobile communications, satellite control and telemetering, and radio astronomy. Continued growth in usage of these services is expected.

³ Final Acts of the World Administrative Radio Conference (WARC-92) Malaga-Torremolinos, 1992, Addendum + Corrigendum.

⁴ Notice of Proposed Rule Making, ET Docket No. 92-9, FCC Rcd 1542 (1992).

⁵ Cerezo, Ernesto A., *Federal Spectrum Usage of the 1710-1850 and 2200-2290 MHz Bands*, NTIA Report 92-285, National Telecommunications and Information Administration, Washington, D.C., March 1992.

NTIA provided testimony⁶ on this subject before the Senate Subcommittee on Communications of the Committee on Commerce, Science and Transportation. In its testimony, NTIA stated that the 2200-2290 MHz band has been deemed available only for Federal Government users for national security reasons. NTIA further stated its plans to review the 1710-1850 MHz band to determine if some accommodation of current non-government users would be feasible. This report documents the results of that review.

OBJECTIVE

The objective of this study was to examine the feasibility of relocating 2 GHz non-government fixed microwave systems into the 1710-1850 MHz Federal Government band.

APPROACH

The study focused on three areas: 1) characterizing spectrum usage of the 2 GHz bands, 2) examining the availability of spectrum in the 1710-1850 MHz band for relocating non-government fixed systems, and 3) examining reliability issues.

The first step in this study was to characterize the use of the 2 GHz spectrum, both Federal and non-government. The Federal band examined was the 1710-1850 MHz bands. The previously referenced NTIA Report 92-285 provided the basis for describing Federal usage of this band. The information in that report was updated where appropriate. The specific non-government spectrum examined was the 1850-1990, 2110-2150 and 2160-2200 MHz bands (hereinafter referred to as 2 GHz microwave bands). An FCC Office of Engineering and Technology Staff Study⁷ served as the basis for describing the 2 GHz non-government microwave bands.

Analyzing the availability of spectrum in the 1710-1850 MHz band for relocating non-government fixed systems was accomplished through use of simplified statistical and graphical methods to show spectrum usage, spectrum availability, and band capacity. Analysis methods developed by both the FCC and NTIA were used and results compared to provide a broad overview of spectrum availability. Inclusion of the analysis method developed by the FCC also provided for ease of comparison with spectrum availability results for other candidate relocation bands provided by the FCC⁸. In the absence of information on specific links requiring relocation, the use of these simplified methods was deemed appropriate to develop best estimates of overall spectrum availability and the potential for accommodation. A detailed link-by-link analysis for specific geographic environments would provide more

⁶ Thomas J. Sugrue, Statement Before the U.S. Senate Committee on Commerce, Science and Transportation, Subcommittee on Communications (June 3, 1992).

⁷ Marrangoni, Paul, et al, *Creating New Technology Bands for Emerging Telecommunications Technology*, Federal Communications Commission (FCC), Office of Engineering and Technology, OET/TS 92-1 (January 1992).

⁸ Ibid.

definitive, yet limited, results. Because the nature of the Federal spectrum use varies significantly from location to location, it would be difficult to draw generalized conclusions from detailed link-by-link studies of a few specific environments.

If 2 GHz non-government microwave systems are to be accommodated into the 1710-1850 MHz band, then suitable guidelines for identifying candidate systems need to be developed. Examination of reliability issues is central to developing these guidelines. No attempt was made in this study to develop a definitive answer to the complex reliability issues. The study focused on reliability issues where there is general agreement among users and design experts. A relocation strategy was developed from these areas of agreement .

SECTION 2

NON-GOVERNMENT USE

OVERVIEW

The 1850 - 2200 MHz band is allocated predominately for non-government fixed microwave use. The private and common carrier microwave use of these bands is described in a staff report prepared by the FCC⁹ and the following description is extracted from that report. TABLE 2-1 shows the non-government statistical data for the 1850-2200 MHz band. Figure 2-1 provides an overall portrayal of non-government fixed microwave use of the 2 GHz microwave bands.¹⁰ There are over 29,000 licensed transmitters throughout the country.

PRIVATE RADIO USE

Private radio systems operate in three sub-bands within the 1850-2200 MHz band: the 1850-1990 MHz band, and the 2130-2150 MHz and 2180-2200 MHz bands, which are available for paired operation. These bands are available for use by the following private radio services: 1) local government including public safety; 2) petroleum; 3) utilities; 4) railroads; and 5) others, including but not limited to manufacturing, banking and service industries.

The types of private systems that use these frequency bands have varying characteristics. Systems range from a few links between buildings to several hundred links. Private fixed microwave systems are used to control electric power systems, oil and gas pipeline systems, and to provide backbone systems for public safety and local government mobile communications systems. Other uses of the band include routine business voice, data and video traffic. The 5 and 10-MHz communications channels are available in the 1850-1990 MHz band. Typical data throughput supports voice, high capacity data and video traffic. The 2130-2150 MHz band, paired with the 2180-2200 MHz band, is channelized into 800 kHz and 1.6 MHz channels. These bands support voice, data and slow scan video. The path length, or distance for operations in this band, range from less than 1.6 km (one mile) to over 160 km (100 miles). The average path length nationwide was determined to be 31.9 km (19.8 miles) for the 1850-1990 MHz band and 24.3 km (15.1 miles) for the 2130-2150 and 2180-2200 MHz bands.

COMMON CARRIER USE

The 2110-2130 MHz band, paired with the 2160-2180 MHz band, is allocated for common carrier fixed service use. These bands are used predominantly by telephone and cellular telephone service providers. Telephone companies use these bands to supply telephone service to remote or sparsely populated areas, and to locations where installing telephone lines is not feasible. The cellular telephone providers employ fixed microwave

⁹ Marrangoni, Paul, et al, pages 9-11.

¹⁰ Figure developed by Comsearch Inc., An Alliance Telecommunications Company, Richardson, TX. Reprinted by permission.

facilities in this band as part of the network backbone to interconnect cell sites with the mobile telephone switching office. These bands are also used by the Improved Mobile Telephone Service (IMTS) for control and repeater functions. The path lengths vary from less than 1.6 km (one mile) to over 160 km (100 miles). The national average path length is 28.8 km (17.9 miles).

TABLE 2-1
NON-GOVERNMENT STATISTICAL DATA FOR 2 GHz BAND

BAND	RADIO SERVICE	LICENSEES	FACILITIES	CHANNEL BW	AVG. PATH LENGTH	Types of Uses	Sample Licensees
1850-1990 MHz Private Radio Services	Local Gov't. Including Public Safety	168	2011	5 MHz 10 MHz	19.8 miles	Fixed Point to Point Control, Voice & Data	LA Sheriff, State of Florida, City of Dallas
	Petroleum	67	2487				Shell, Chevron, Exxon
	Power	164	3197				Georgia Power, Dairyland Power Cooperative, Interstate Power
	Railroads	18	895				Union Pacific, Burlington Northern, Missouri Pacific
	Others	143	668				Citibank, Hewlett-Packard, Procter and Gamble
1990-2110 MHz ^(*) Broadcast Services	Broadcast Auxiliary	916	7359	17 MHz	30.4 miles (fixed)	Fixed and Mobile Broadcast Auxiliary - STL, ICR & ENG	ABC, CBS, NBC, Westinghouse
2110-2130/ 2160-2180 MHz Common Carrier Services	Telephone/ Cellular Paging	481	6823	3.5 MHz	17.9 miles	Fixed Point to Point Cellular cell tie line & local telephone remote tie line One-way Paging	Southwestern Bell, U.S. West, McCaw, GTE
2130-2150/ 2180-2200 MHz Private Radio Services	Local Gov't. Including Public Safety	549	4052	0.8 MHz 1.6 MHz	15.1 miles	Fixed Point to Point Control, Voice & Data	Commonwealth of Pennsylvania, State of California, Commonwealth of Virginia
	Petroleum	111	2933				Mobil, Amoco, Arco
	Power	258	3521				Pacific Gas and Electric, Southern California Edison, Allegheny Power
	Railroads	24	991				Atchafalaya Tapska and Santa Fe Railway, CSX, Denver and Rio Grande Western
	Others	363	1538				Motorsola, University of Maryland, Norstar bank
2150-2160 MHz ^(*) Common Carrier Services	Multipoint Distribution	65	163	6 MHz	NA	Point to Multi-point Video Distribution (Wireless Cable)	Moreband, Contemporary, Broadcast Data

* No reference to these bands is given in the text.

(from, FCC, OET/TS 92-1, 1/92)

(This figure was generated by Comsearch 7/92.)

Section 2

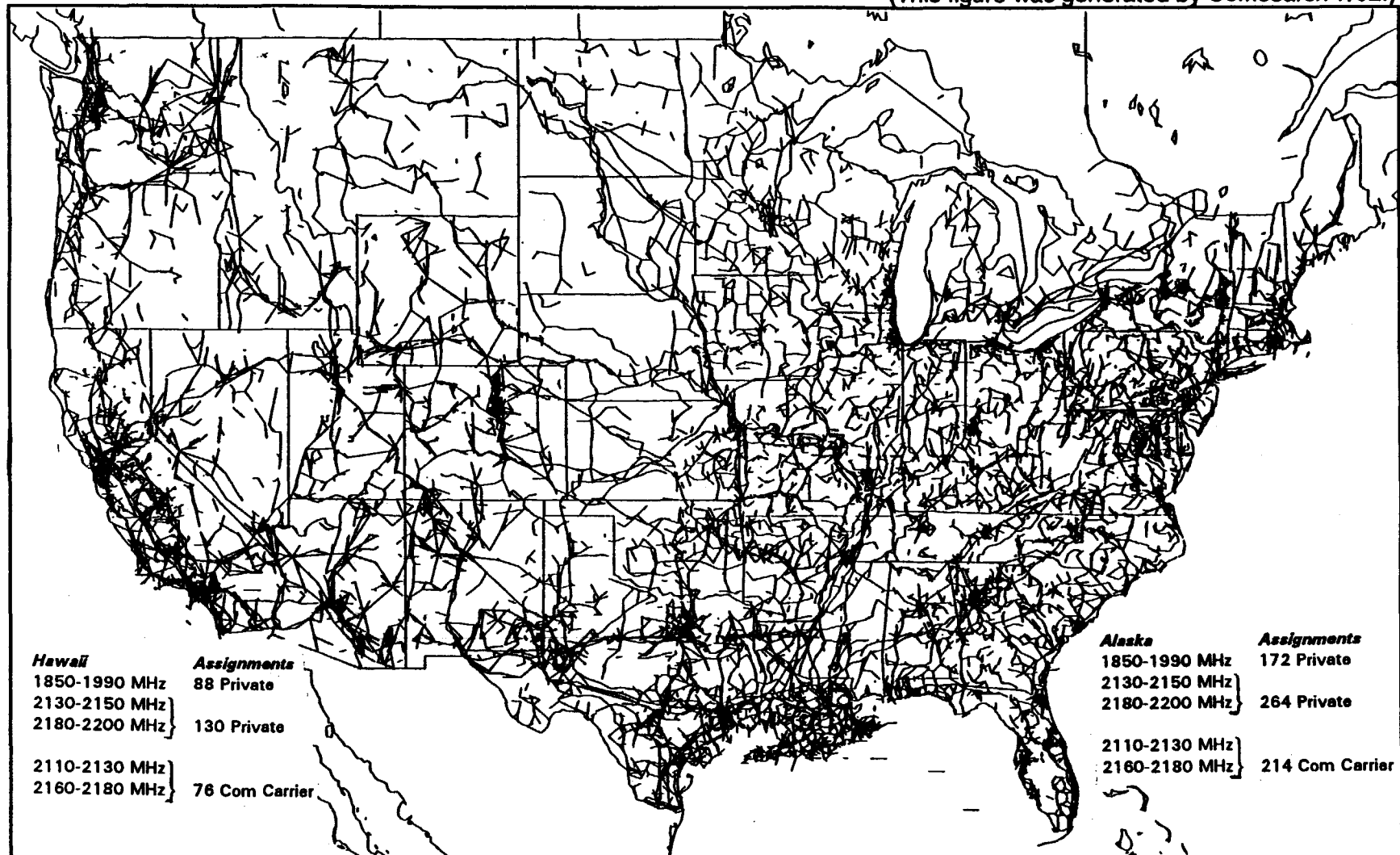


Figure 2-1. Non-government fixed microwave use in the 1850-1990, 2110-2150, and 2160-2200 MHz bands.

Non-Government Use

SECTION 3

FEDERAL GOVERNMENT USE

OVERVIEW

The Federal Government, pursuant to various public laws and international treaty agreements, performs a variety of missions that require use of the radio spectrum. In the 1710-1850 MHz band, radiocommunications for normal and emergency purposes include the following services for the public:

- Providing control and tracking of over 85 military satellites
- Providing comprehensive and realistic training of military air and land mobile forces
- Providing real-time transmission of test data from military research and development projects
- Providing emergency response and public safety land mobile units
- Providing early warning to the public from major catastrophic events
- Provide for realistic training to civilian and disaster response teams
- Providing Air Traffic Control support to the National Airspace System
- Controlling vessel traffic in major port areas
- Promoting aviation safety and efficiency
- Enforcing drug interdictions, and customs and immigration laws
- Managing National Parks, National forests and Federal Wildlife Refuges
- Generating and distributing electrical power to utilities and industry in 23 States
- Exchanging social, environmental, health and educational information between countries of the Pacific Basin
- Supporting the nuclear waste management program
- Verifying compliance with international treaty agreements concerning nuclear explosions and arms control
- Collecting weather information and distributing this real-time information to radio and television broadcast stations

Federal radiocommunications operating in the 1710-1850 MHz band include fixed and mobile services, various space services and the radio astronomy service.¹¹ These uses are authorized by NTIA and recorded in the Government Master File (GMF) of frequency assignments by NTIA. As of July 1992, there are 6924 Federal assignments recorded in the GMF. It is important to note the distinction between the number of recorded assignments and the number of equipments in use. For example, for conventional fixed microwave systems, one assignment generally represents one "equipment," a transmitter/receiver pair. For other types of uses such as transportable and mobile systems, an assignment may represent many equipments. The 6924 assignments in this band represent over 12,000 transmitters. Figure 3-1 gives a graphical description of the varied uses of the 1710-1850 MHz band from the fixed microwave links to the space shuttle applications. As shown in Figure 3-2, these applications are widely distributed across the United States. The number of Federal assignments, equipments and estimated investment are summarized in TABLE 3-1. The following paragraphs describe each of these services in more detail.

¹¹ Cerezo, Ernesto A., pages 4-1 to 4-12.

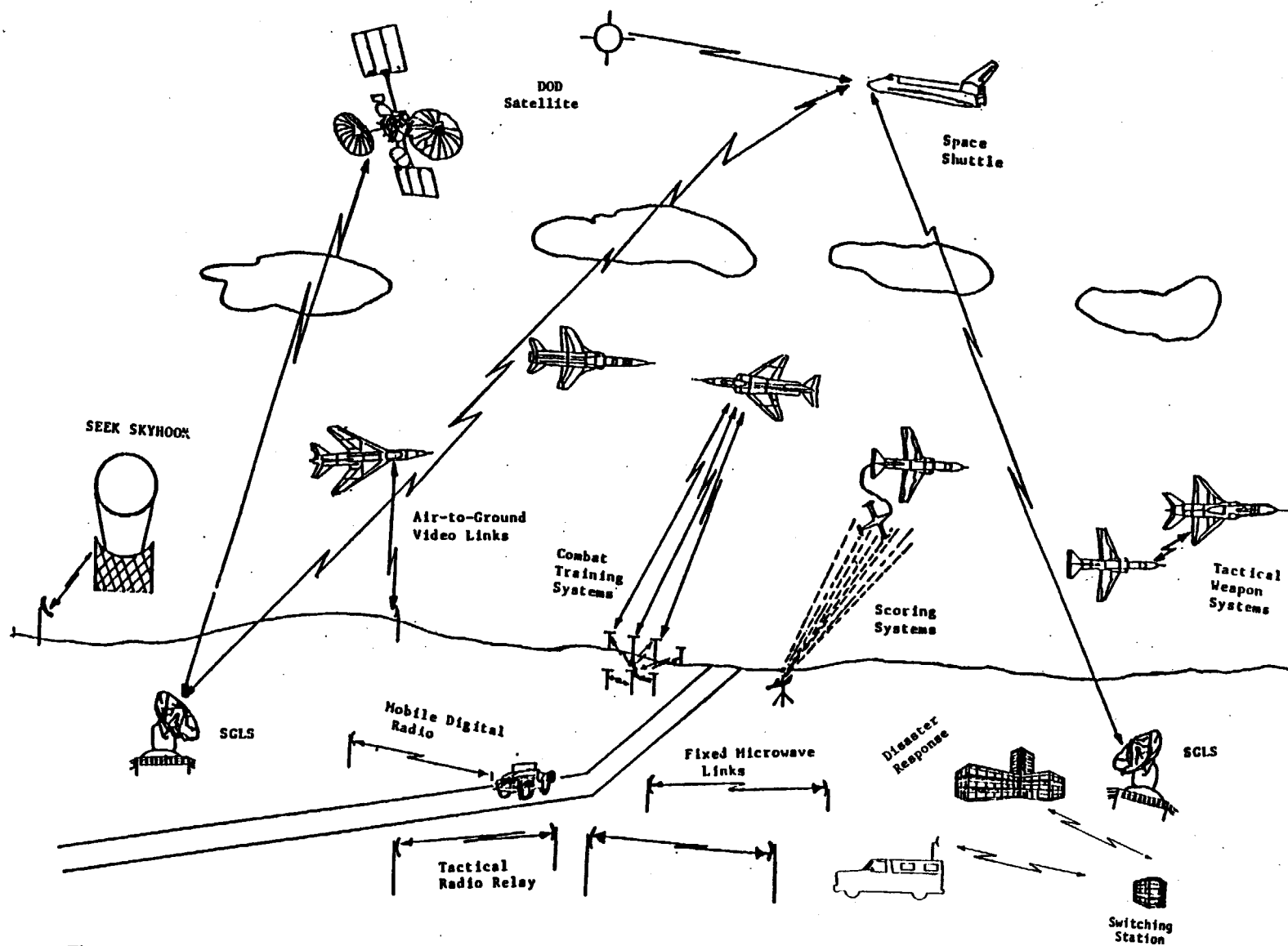


Figure 3-1. Graphical description of the wide uses of the 1710-1850 MHz band.

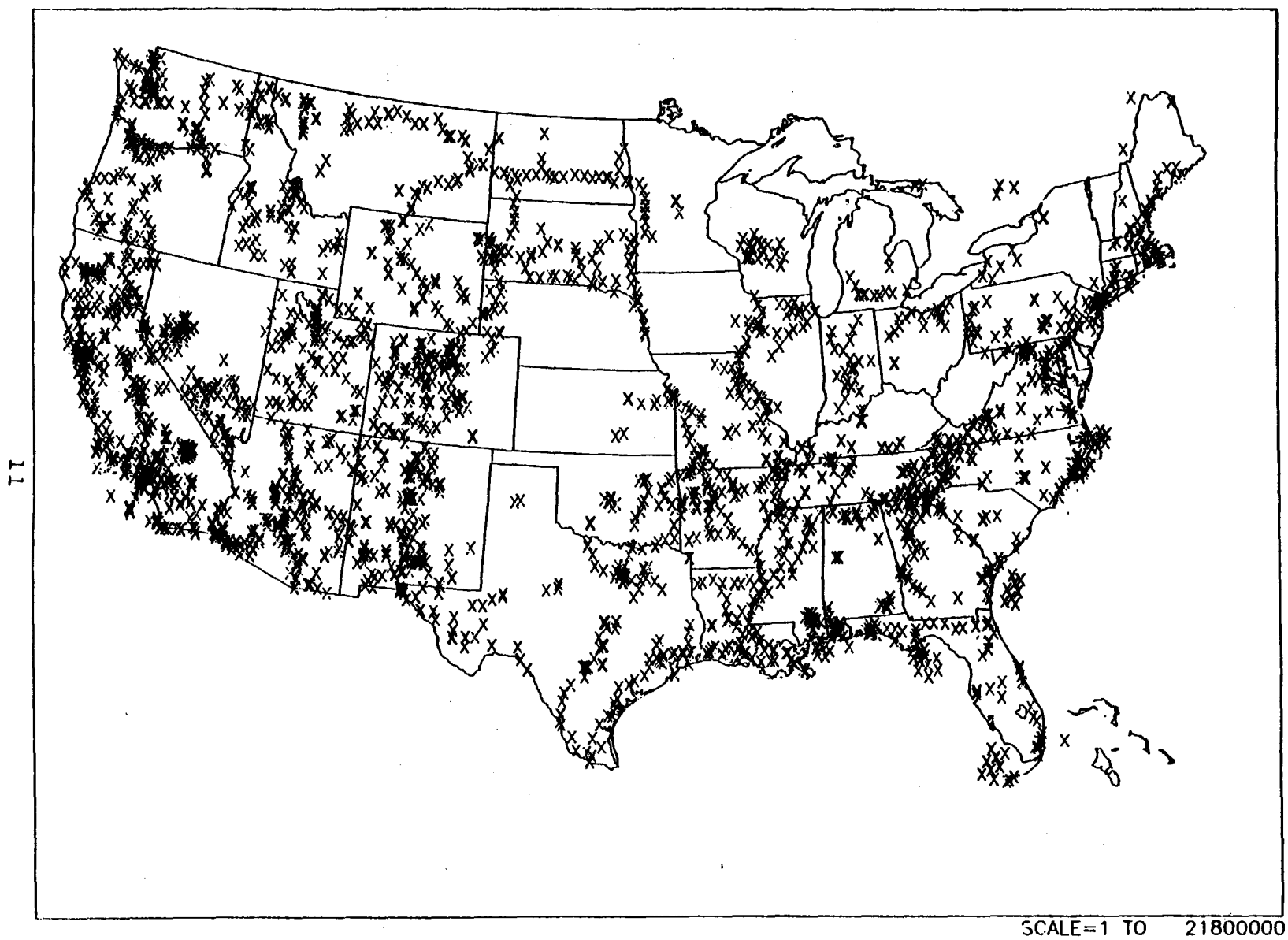


Figure 3-2. Geographic distribution of Federal Government fixed assignments in the 1710-1850 MHz band.

TABLE 3-1
MAJOR SYSTEMS in the 1710-1850 MHz BAND

<u>Systems</u>	<u>Frequency (MHz)</u>	<u>Assignments^a</u>	<u>Equipments</u>	<u>% Equip</u>	<u>Investments</u>
FIXED					
Conventional Microwave ^b	1710 - 1850	5150	5150	42	\$700 million
Tactical/Transportable	1350 - 1850 ^c	1014	3000	24	> \$1 billion
Air Combat Training Systems	1710 - 1850	142	(see ^d)	(see ^d)	(see ^d)
Troposcatter ^e	1700 - 2300	16	16	0.1	\$12 million
SPACE					
Ground Facilities (worldwide)	1761 - 1842	230	> 30	0.2	\$700 million
Satellites			> 85	0.7	> \$10 billion
MOBILE					
	1710 - 1850	372	> 4000	33	> \$400 million
Air/Ground Video Systems		65			
Air Combat Training Systems		217			
Target Scoring/Weapon Systems		34			
Miscellaneous Mobile Systems		56			
RADIO ASTRONOMY					
(Unprotected Basis)	1718.8 - 1722.2		10 sites	0	\$70 million
TOTALS					
		6924	>12,000	100	> \$12.8 billion

^a - as of July 1992
^b - major Federal agency users include Agriculture, Justice, Energy, Interior, FAA and Coast Guard.
^c - Army is anticipating another 600 to 700 assignments to more accurately reflect current use.
^d - included in the mobile totals
^e - used to support emergency preparedness programs
> greater than

FIXED SERVICE

Conventional Fixed Microwave

This class of systems represents the largest group of assignments (5150) in the band. These systems used by the Federal Government are similar in function and characteristics to the non-government fixed microwave systems in the 1850-2200 MHz band. TABLES 3-2 and 3-3 provide a summary of typical functions and technical parameters along with data for the non-government bands for comparison. Generally, for the conventional fixed microwave systems, one assignment represents one equipment, and with few exceptions, the equipment used is commercial off-the-shelf equipment. All require high reliability communication service similar to non-government applications.

Tactical/Transportable Radio Relay

The tactical/transportable radio relay systems provide for command and control of the military land mobile forces. These multichannel radios provide up to 64 channel capacity and are extensively used within the United States to provide comprehensive and realistic training and to maintain a high level of combat readiness. The 1014¹² assignments in the GMF represent approximately 3000 radios in the Department of Defense inventory. The principal characteristics that distinguish these radio operations from the conventional fixed systems lie in their transportability and tunability, both basic principles of tactical military operations. Their transportability means that they have mobility for quick reaction time but cannot transmit while in motion; they stop, set-up and within 4-6 hours, they can transmit. The transportable systems provide the interconnectivity to link the various tactical units at the subordinate and headquarters level into an integrated area-wide network. Linkage through line-of-sight radio relay is critical to the successful integration of joint and allied exercises. The assignments represent a variety of older and new equipments.

TABLE 3-4 gives a summary of the key technical and operational characteristics of these tactical radios. The 500 MHz tuning range of the radios covers three bands, namely 1350-1400, 1427-1435 and 1700-1850 MHz, that permit operation on a primary basis. Spectrum requirements at large Army training areas such as Ft. Irwin, CA (National Training Center), Ft. Chaffee, AR (Joint Readiness Training Center), Ft. Hood, TX and Ft. Bragg, NC, may require up to 200 simultaneous links during large coordinated training exercises. Typical Army bases require on the order of 30 assignments or less.

The frequency range 1350-1850 MHz provides many desirable traits in satisfying tactical command and control network connectivity including lower power requirement, adequate bandwidth and ease of installation.

¹² By September/October 1992 DOD anticipates an increase of 600 to 700 assignments in the tactical/transportable assignment count, due primarily to more accurately identifying assignments with existing radios.

TABLE 3-2
COMPARISON OF GOVERNMENT VS NON-GOVERNMENT
ALLOCATED SERVICES AND FUNCTIONS USED AT 2 GHz

SERVICES ALLOCATEDFederal Government (1710-1850 MHz)Non-Government (1850-2200 MHz^a)

Fixed

Fixed

Mobile

Satellite

Radio Astronomy

FUNCTIONS UTILIZEDFederal Government (1710-1850 MHz)Non-Government (1850-2200 MHz^a)

Federal Law Enforcement/Public Safety

Local Government/Public Safety

Transportation Safety (Airlines)

Transportation Safety (Railroads)

Power Generation/Distribution

Power Generation/Distribution

Natural Resource Management

Petroleum

National Defense/Security/Disaster Responses

Common Carrier Phone Lines

^a Does not include the band 2150-2160 MHz

TABLE 3-3
TECHNICAL CHARACTERISTICS OF GOVERNMENT / NON-GOVERNMENT
CONVENTIONAL 2 GHz FIXED MICROWAVE SYSTEMS

	Federal Government 1710-1850 MHz (140 MHz)	Non-Government 1850-1990 MHz (140 MHz)	Non-Government 2110-2200 MHz ^a (80 MHz)
Power (Watts)	0.25 to 5	0.25 to 5	0.25 to 5
Antenna Gain (dBi)	25 to 33	29 to 33	29 to 33
Path Length (km/mi)	35/22	32/20	26/16
T/R Separation (MHz)	50 to 90	80	50
Bandwidths (MHz)	0.8 to 10	5 to 10	0.8 to 3.5
<p>^a Does not include the band 2150-2160 MHz.</p>			

TABLE 3-4
COMMAND COMMUNICATIONS FOR FIXED ARMY
TACTICAL/TRANSPORTABLE UNITS IN THE 1350-1850 MHz BAND

Tunes Over the 1350 - 1850 MHz Band
Tunes in 1 MHz Increments
1.2 MHz Bandwidth
200 MHz Available on a Primary Basis (140 MHz in the 1710-1850 MHz band)
Specific Channels Assigned
Extensive Use on a Locally-Assigned, Non-interference Basis
Heaviest Spectrum Requirements are Located at National Training Center, Ft. Irwin, CA and Joint Readiness Training Center, Ft. Chaffee, AR

TABLE 3-5
HIGH POWER FIXED TROPOSCATTER COMMUNICATION LINKS

Supports Emergency Government Communications
Limited Number (16 assignments)
Frequency Diversity
Current T/R Separation of 55 MHz
Up to 10 kW; 36 dBi Antenna Gain
Long Range Interference Effects

Air Combat Training Systems

These systems employ both fixed and aeronautical mobile components and are discussed under the mobile service in the air combat training systems.

Fixed Tropospheric Scatter

Most fixed systems operate in a line-of-sight mode of operation, that is, with no obstructions between the transmitter and receiver. Tropospheric scatter communication relies on the fact that a small amount of radio waves under certain conditions is scattered from irregularities in the troposphere as illustrated in Figure 3-3. With sufficient transmitter power and 800 km highly sensitive receivers, reliable communications can be obtained over distances better than 300 km¹³. TABLE 3-5 (previous page) describes the tropospheric scatter communication links which are used for emergency communications, in the 1710-1850 MHz band.

MOBILE SERVICES

The Federal Government, primarily the military services, operates a variety of mobile systems in the band to support combat training, and research and development activities. The predominate use of the mobile service is at military bases and the various National Test and Missile Ranges. Much of the spectrum use at the test ranges are locally scheduled and coordinated. Figure 3-4 shows the location of these test ranges and the area of cognizance for the local frequency coordinators. In addition, emergency response and public safety organizations operate and conduct large scale exercises to prepare for and respond to a wide variety of emergencies and disasters, such as hurricanes, earthquakes, chemical and nuclear power plant accidents.

Air Combat Training Systems

These systems are used by the military at more than 17 sites across the United States to provide realistic tactical simulation and pilot training in a peacetime environment. Training is provided in air warfare operations and maneuvers without actually firing the weapons. The systems provide real-time altitude, location, velocity, angle of attack, simulated weapon status and other data on up to 36 participating aircraft. The system has gone through a series of upgrades and name changes, including the Air Combat Maneuvering Instrumentation, Air Space Position Measuring System, Air Combat Maneuvering Range and Tactical Aircrew Combat Training System. A typical configuration for a system, shown in Figure 3-5, consists of a master control station, six or seven remote tracking stations and up to 24 participating aircraft. The geographical area of coverage is up to 65 km and may remain in operation for up to 10 hours per day. Altitudes of up to 15000 feet are typical during exercises. Recent system upgrades provide for multiple control stations and up to 36 aircraft. These are tied

¹³ Mellen, G.L., et al., "UHF Long-Range Communication Systems," Proceedings of the IRE Conference on Scatter Propagation Issue, 1955, pp. 1269-1280.

together via radio links, nine or ten of which are required for each system. A number of ACMI sites are being planned at classified locations throughout the United States.

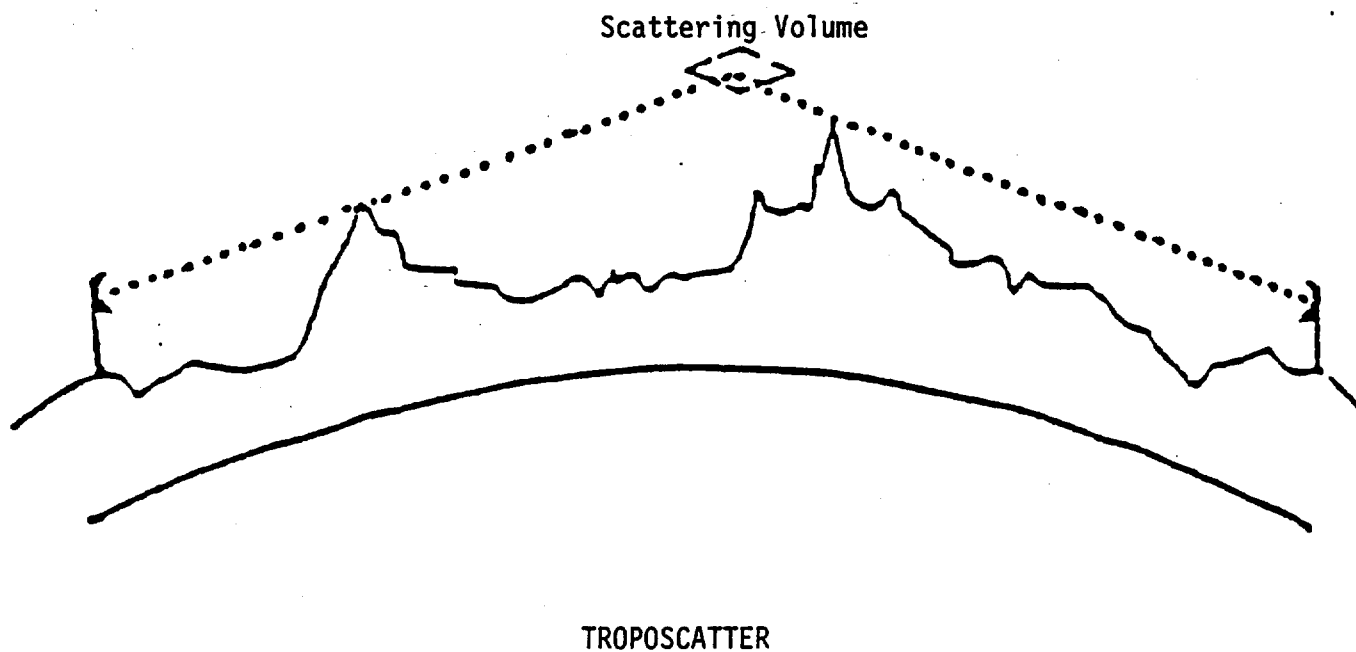


Figure 3-3. Tropospheric scatter communications relies on scattering from the troposphere.